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ESTIMATING POPULATION SIZE AND GROWTH FROM INADEQUATE DATA

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Estimating population size and growth from inadequate data

Karol J. Krótki

In approaching population data from underdeveloped countries, three biases are operationally useful: rate of growth is more important than size; population figures refer to the past; and the reliability of figures in suspect. Post-enumeration surveys have become a feature of the best work. In dealing with inadequate data, the following tools of analysis are put forward: age distribution by application of the quasi-stable population theory, and the population growth estimation experiment (the Chandra-Deming formula) as first applied in Pakistan. Age distributions can also be applied to urban migration, seasonality in vital events and life-cycle stages. The author concludes with some remarks about the denominator.

A visitor to the Department of Commerce in Washington, D.C., standing in front of the population clock in the main hall may be unduly impressed by the apparent precision with which population changes in the United States are being recorded through births, deaths, immigration and emigration, though the relevant data are reasonably accurate, even if not quite as accurate as, say, in England or the Netherlands or the Scandinavian countries. Not that it would matter a great deal if the data were less accurate. The emphasis in demographic research would switch somewhat from the substantive meaning of the figures towards considerations of their accuracy, but the economy of the country as a whole would continue at its buoyant pace, perhaps just a shade more erratically.

The problem and its prevalence

It is in the underdeveloped countries living at the margin of subsistence in circumstances where a slight difference in any one variable in the economic analysis can make all the difference between stagnation, even failure, and slight success that population is quite a critical factor, and yet it is in these same countries that the data are usually uncertain. The majority of the populations of the world are in this category. This uncertainty and its wide prevalence as revealed in the United Nations Development Decade acted as a stimulus to the development of analytical tools designed to narrow the margin of uncertainty.

When confronted with inadequate data the demographer has three courses of action open to him: to collect improved data (e.g., Cavanaugh, 1963), to correct analytically data already collected (e.g., Clairin, 1964), or to collect substitute data (e.g., Blacker and Martin, 1963; El-Badry and Chandrasekaran, 1963). The first course of action, improvement of the data, involves a methodological study of survey practices and is outside the scope of this article.[1] The present writer having spent half his professional life collecting poor data has devoted the other half to correcting it analytically and through special surveys. The purpose of this article is to describe some of the gimmicks and tricks of the trade available to a demographer confronted with inadequate data. It is based on the writer's practical experience and biased by it. The frequency of references to his own work is in no way indicative of his role in the development of theory and only partly explainable by the extent to which he applied the theory to practical needs.[2] Before presenting several instances of estimation on the basis of inadequate data a few generalities are in order. They are intended to give the flavour of the climate in which one operates when dealing with such data.

When dealing with population data from an underdeveloped country it is useful to approach it with three biases.[3]

The first one is that *it is usually of much greater importance to the country concerned to know the rate at which its population grows rather than its population size*. There are two reasons for this. Firstly, whatever the size is, *it is*. Even if the most sophisticated application of the theory of 'optimum population' were to suggest that the population of a given territory should be half of what it is, this is not an operational finding. There is nothing one can do about it. The second reason is that certain methods of national product estimation for some sectors of the economy may depend on the very population size. Changing population size changes proportionately the contribution of the given sector to the national product and leaves the national income per head of population largely unchanged.[4] The rate of growth, on the other hand, is of immediate interest: it can be compared with the rate of growth of the economy and—we are told by workers in the field of family planning—it can be manipulated by an appropriate population policy. The effectiveness of present approaches to the problem can be

1. Also excluded is the whole field of, mainly arithmetical, devices for correcting misreported information, such as mis-stated ages. Some of them are exceedingly sophisticated (e.g., Carrier and Farrag, 1959) and the United Nations have published whole textbooks on the subject. Their frequent weakness is inability to treat selective underenumeration and variations in enumeration completeness between censuses.
2. The writer is aware of at least a sizeable proportion of the many and varied interesting endeavours by his colleagues in this field, but it is not possible to do justice to them in a 5,000-word article.
3. The second bias, and probably the third one, are useful also with regard to developed countries, but they are not the concern of the present article.
4. If this argument is correct then the suggestion to the effect that 'in developing countries a proper enumeration of the population is the first operation to be carried out before instituting a development plan' (Chevry, 1965, p. 2) would appear to have its emphasis misplaced.

doubted, though first swallows of effective population policies have been reported from India (Population Council, 1963*a*, p. 4) and possibly from Ceylon (Population Council, 1963*b*, p. 11).

A second useful bias is the understanding that *a population figure never is. It always was* at some date in the past. This understanding is important not so much to avoid such obvious mistakes as to say in 1965 'the population of X is' and then quote a 1961 figure. More than that, it is necessary to induce a state of mind appreciative of population dynamics. A population may have had a high birth rate over the recent decade, but as a result of events a couple of decades ago there may be a (temporary) shortage of mothers just now and, even though the fertility of each mother is the same, there will be a drop in the birth rate. Or to take another example: until recently Japan was a strong contender for fifth place in the population size league. Today there is no doubt that while Japan is successfully applying all possible (and elsewhere impossible) means of delaying its slide past the 100 million mark, both Pakistan and Indonesia have rushed ahead and are well beyond the same 100 million mark.[1]

The third bias necessary is to *suspect the reliability of figures*. A phenomenon in the data need not be a true demographic fact. Let a few examples be quoted. A country shows three widely differing rates of increase between four enumerations (28, 18 and 15 per cent). However, when only population above the youngest ages is considered the changes become less remarkable (23, 21 and 17 per cent). On investigation it is found that there was differential under-enumeration of children at the various censuses (Bourgeois-Pichat, 1953*a*). Again a country with only one census and no registration of vital events shows a low infant mortality (IMR) in relation to adult mortality, in relation to fertility and in relation to its general level of development. When compared with a large number of other countries, where, incidentally, infant mortality appears to be underestimated, the reported IMR of 94 (children dying within one year out of each 1,000 born) has been increased to an estimated minimum of 140 and possibly 200 (Krótki, 1961*a*). Or again, an extensive analysis of Greek data has been undertaken on the assumption that the various quantities reported for ages, sexes and periods (first week of life, first month of life, etc.) must stand to each other in some relation not very different from that obtaining elsewhere (Valaoras, 1965). As a result of this analysis, a large number of reasonable adjustments were made to monthly registrations, to total annual registrations, to parts of age-specific mortality rates, to various sex ratios and so on.

Some investigations do not depend on any one approach, but rest like involved detective work on a whole series of considerations, each individually fragile, but cumulatively coherent. Some are ingenious and, being based on theory, can be used again in similar circumstances. Some others

1. It is interesting to note that this identical development must have been quite independent of the pro-natalist policies of one Government (Indonesia) and the anti-natalist policies of the other (Pakistan).

provide corroborative evidence in one instance and cannot easily be extended over other cases. With particularly fertile writers the wealth of demographic and non-demographic facts which can be unearthed through the use of demographic analysis is quite amazing (e.g., Lorimer, 1946).

Peculiarities of field checks

'A population census is not a census of people but a summary of a large number of pieces of paper which originally have been produced with some reference to some of the people living in a territory and have since been subjected to all the vicissitudes of sorting, tabulating and other modes of mistreatment. A so-called *complete* or *full-count* census is never complete, and, not having been done on a sample basis, it suffers from low quality inherent in a large-scale task. It is only when the remoteness between reports from so-called *complete* censuses and the population is realized that census results can be discussed dispassionately' (Krótki, 1964). This somewhat overdrawn picture has been painted by the present writer in order to free an important group of people from their attachment to the printed and 'official' census results.

Demographic analysis has repeatedly indicated that census results fall short of reality by a considerable margin. Only a few examples need be mentioned: 5 million in 1950 in the United States (Coale, 1955), 8 million in 1961 in Pakistan (Krótki, 1963*b*) and 20 or 25 million in 1951 in India (Coale and Hoover, 1958, p. 354).

Post-enumeration surveys

Field checks of field work must not be viewed as alternative to sophisticated office checks or as supplements required only by inadequate field work during the original survey. They have become an indispensable part of the best surveys. There are many examples of field inquiries into the reliability of field results.[1] There is at least one example of adjustments arising out of a field inquiry actually punched into the cards in the form of various raising factors for affected age and sex groups (the First Population Census of Sudan, 1955-56). More generally, census takers while recognizing the need to report on post-enumeration checks are slower in making the actual adjustments in their results. This is, of course, justified when the results of the check are as suspect as the main job, but may also be due sometimes to the impossibility of cutting across established interests.

A repetition gives response variances, but does not avoid biases

A repetition of a survey under identical circumstances gives the variations in characteristics obtained by identical tools of measurement (like obtaining

1. Though reports on such activities are less numerous.

two results while measuring the length of a house with the same tape). There is a growing literature on the subject of viewing a full-count census as only one of a number of random outcomes of a universe of alternative possibilities with results shattering to the complacency of survey-users in the case of at least some characteristics (e.g., Fellegi, 1964).

It must be obvious that a repetition of an inquiry under the same conditions, even if carried out by the 'best' enumerator[1] (Krótki and Hashmi, 1962, p. 377), can be no solution to the detection of any biases inherent in any given method. The problem is often recognized, but avoided by recourse to the suggestion that post-enumerators should be superior in their training and conditions of work (Vangrevelinghe, 1965, p. 3). With a repetition, even if superior, the same errors of bias are likely to be repeated (ibid., p. 2). In the submission of the present writer the failure of such surveys to come up with results hoped for is not necessarily to be sought in the inherent intricacies of a post-enumeration survey (ibid., p. 4), but in their repetitiveness. Even when a *complete* field check is carried out, as in the U.S.S.R. (Taeuber, 1965, p. 4), the relevant question remains whether it was a repetition or an enumeration from a different angle. A repetition may disclose response variances, but like a wrongly-numbered measuring tape, it will not detect biases of the measuring method.[2]

Post-enumeration surveys an ultimate and inevitable feature

The tools in the hands of social surveyors are being refined daily. The progress in the field of sampling theory and design, computer-related complex estimations, improvement and evaluation of response, rigorous methods of field control and technological developments in data processing (Linder, 1965), is rapid. There is no doubt that the increasing consciousness of the duty of checking one's own results as critically as possible and reporting openly to the users on the checks will increase the use of post-enumeration surveys. A frank appraisal openly arrived at is becoming an unavoidable feature of a survey report. However, this will take time to become generally recognized and practised. In the meantime the best use must be made of inadequate data by other means.

Age distribution a powerful tool of analysis

Age pyramids with wiggles, usually in the middle ages and usually more pronounced on the male side, are well known. Such wiggles may show war losses or losses by emigration when concave or gains by immigration when convex. Only relatively recently has it been established that changes in births have a much more pronounced influence on the proportionate age

1. Particularly when there are no clear criteria indicated for the selection of the 'best' enumerator.
2. 'We did it again and came up with the same results' could be as misleading as any other of the statements with which humanity likes to reassure itself.

distribution than changes in death. A common-sense explanation of this phenomenon is that changes in mortality are not, by and large, age selective. One cannot improve the health conditions of people aged 25 and not improve at the same time the health conditions of people aged 30. Thus the proportionate effect of a change in mortality on the age distribution pyramid is slight: like a growing onion it may add a layer throughout the length of each side, or, less frequently, shed an edge with increasing mortality, but the proportions at various ages do not change drastically. Even the celebrated and much discussed ageing of populations is not, in the first instance, the result of improvements in mortality. In fact, it has been shown empirically (Coale, 1956) that in more than half of the populations experiencing improvements in mortality (i.e., a lengthening of life expectation) the proportions at old ages are decreasing. Lorimer in 1951 and Sauvy in 1954 have shown that but for the improvements in mortality resulting in younger populations the actual ageing of populations which was taking place due to falls in fertility would have been even greater.

The decisive influence on age distribution is changes in fertility. A drop in birth rate from 40 to 20 would halve the base of the age pyramid and after a period of years would make the entire pyramid half as slim. A halving of the death rate, on the other hand, from, say, 20 to 10 would distribute itself over all ages—even if in somewhat varying proportions—and would leave the relative age distribution largely unchanged. The impact of the birth rate is concentrated at one age only, age zero. Hence the dramatic effect on the age pyramid.

The quasi-stable population theory

The theoretical apparatus covering all these possibilities goes under the name of a stable population theory (Lotka, 1939), which says that, no matter what the original age distribution, so long as a population is closed to external migration and has fixed age and sex schedules of fertility and mortality, populations will eventually develop one and only one age distribution. The theoretical concept of a stable population seldom had a counterpart in reality, but since the discovery that mortality does not, within reason, shape the relative age distribution the analytical usefulness of the stable population theory has been immensely increased under the general heading of the quasi-stable population theory (Coale, 1963 and the literature quoted therein).

Reliability of birth estimates

Ideas about fertility can be formulated from the shape of the age pyramid: if slim—fertility is low, if with a wide base—fertility is high. If, then, ideas about intercensal growth can somehow be obtained, mortality is a mere residual obtained by subtracting growth from fertility. If ideas about intercensal growth are uncertain in the case of the total population, then

perhaps one or two age groups could be compared and, in the absence of migration, views could be formed about the attrition experienced by such age group or groups between the two censuses. The mortalities at different ages being highly correlated at any one level of general mortality, the rest of the mortality curve can be deduced, under favourable circumstances, from one part of it. However, in the absence of exact age reporting this is an uncertain procedure and one is never too sure about mortality. The wide base of the age pyramid, on the other hand, is usually there, whatever the misreporting, to point to a high birth rate.

Some anxiety has been expressed (Demeny, 1965) that mechanical approximation of populations in the process of destabilization to stable populations can lead, especially with rapidly changing mortality conditions, to patently wrong results. Now there are some reasons why a drop in mortality affects age distribution, particularly when it takes place from a high level of mortality. It does so through fertility. 'Ill-health can be a cause of inability to conceive, of premature abortion and of stillbirth. High mortality rates are a cause of frequent widowhood and thus of reduced fertility. Since mortality decline is associated with decreased morbidity and increased chances of survival during reproductive years of life', 'even if there is no change in age-specific fertility, there may be an increase in crude birth rates' (United Nations, 1964, p. 27, 33). Apart from this source of interdependence between mortality and fertility, there is a mathematical dependence working through age distribution. The actual degree of this dependence and the size of the ultimate difference between stable rates and destabilized rates depends on several considerations: the age pattern of the mortality decline, the rapidity of the decline, the time elapsed since the decline began, and the recent persistence of the decline (Coale, 1963*a*, p. 182). In extreme cases the birth rate estimated from an age distribution could be different from the actual birth rate by four births per thousand of population (Demeny, 1965), or less than ten *per cent* with birth rates over forty.

There are other sources of trouble with age distributions. There are those age pyramids (single years of age) which look like Christmas trees with longer branches at ages ending with 0 and somewhat shorter branches at ages ending with 5. The practitioner is little perturbed by the smoothing of such pyramids. There are standard ways of doing this and the usefulness of such age distribution is no smaller than of others. However, at least one case must be reported where age misstatements around age 10 at two successive censuses were so severe and blended with strong migrational effects (the 1947 partition of the Indo-Pakistan sub-continent) that they opened the whole question of the usefulness of the relevant age distributions (Krótki, 1965). However, even in this case it was possible, with a bit of artistry, to arrive at acceptable vital rates (Krótki, 1963*b*).

Unreal worry about birth rates

There is something of a circular argument about the worry that destablization may lead to wrong readings. The mortality schedules of populations in underdeveloped countries are not known although for surveys giving proportions of children surviving very ingenious ways have been suggested of producing life tables (e.g., Brass, 1963). The existing model life tables[1] cannot therefore be applied with assurance, but that of course was only too obvious all along the line, because if they were known it would not be necessary to apply model mortality conditions. If known, they themselves would go towards making model life tables. (Moreover, inasmuch as these mortality conditions are now rapidly changing and at least the higher levels are being deserted fast, they may never be known.)

When an attempt has been made to estimate the historical birth rates of India and its parts (Saxena, 1965), readings for any one part of India at any one point of time differed by ten and fifteen births per 1,000 population because of misreporting and irregularities in age reporting. The extreme difference, quoted earlier and seldom encountered, arising out of destablization, was four births.

The teachers and students at the United Nations Centre for Demographic Training and Research at Chembur have applied several methods to several populations (Chandrasekaran, 1964). Their main difficulty appears to have been the crudeness of their material and the consequent impossibility of applying more refined methods.

In such circumstances the burden of the analysis switches to detective work piecing together considerations, 'each individually fragile, but cumulatively coherent' (to quote an earlier sentence), Once somehow such a defective age distribution has been reconstructed the mere application of the theoretical apparatus is a small matter.

Unreliability of death rates

All that one can expect from model life tables is a general indication of what might have been the situation, very approximately, at any one age once ideas have been formed about the general level of mortality. The age-specific mortality must have been U-shaped, high at young ages, low in the middle and high again at old ages. The downward leg of the U must have been dropping more rapidly (though not necessarily for little girls as the masculinity ratios tend to rise at the tender age of 3 for some populations; Krótki, 1963*b*, p. 298) and the upward leg of the U must have been rising more slowly, but that is about all that can be said.

1. The most popular are the United Nations model life tables, only one of a series of imaginative and yet painstaking publications, veritable milestones in the advancement of demographic theory, which make any newcomer to the field wonder how it was possible to operate at all before the advent of the Population Branch at the United Nations (United Nations, 1955). For many years the model life tables did sterling service with a dozen pages. A much closer approximation to reality is just about to appear in print, but it will take almost a thousand pages (Coale and Demeny, 1964).

Should there have been good age reporting in at least two censuses, and no migration between censuses, the survivors at the next census when compared with their own age group at the previous census could provide excellent evidence on mortality, but this is seldom the case. Usually there are several influences confusing the situation and allowing for a variety of explanations. A leading researcher in the U.S.A. working on an Asian country in a leading demographic centre, having gone through a series of alternatives, concluded with almost audible disgust: 'There must be some other cause.'

There is something unreal in the attempt to introduce further refinements in the crude tools available. Interest in mortality must be unprofitable on the basis of an inadequately reported age distribution. There are good reasons why changes in mortality do affect age distribution.

Births and conceptions

Births are considered by some analysts as a poor indicator of conceptions when used as a measure of success or failure of family planning campaigns. Inasmuch as such campaigns may be associated with an improvement in general standards of health, the previously and prematurely lost conceptions may now terminate in live births and counterbalance the effects of family planning. To the extent that this argument is valid, the usefulness of the age distribution is also impaired. However, at birth rates equal to fifty and more, there cannot be too much room for a difference between births and conceptions, while an age distribution obtained from the next enumeration would show a narrowing of its base, with a true birth decline.

The PGE experiment

The PGE (Population Growth Estimation) experiment has been described on several occasions (e.g., Ahmed and Krótki, 1963). It is a field operation going on since the end of 1961.[1] It covers twenty-four areas in Pakistan selected at random, each with just over 5,000 people. Its purpose is to collect accurate vital rates, but also a variety of ancillary items of demographic data of a quite outstanding and unique nature. In essence the experiment consists of two independent operations: a continuing registration and a quarterly enumeration. The records arising out of these two independent operations are compared event-by-event at headquarters.[2] During this matching operation the records are divided into three categories: those matched, i.e. caught by both operations, and the two lots

1. The PGE experiment costs about $100,000 annually, financed partly by the Government of Pakistan and partly by the Population Council of New York (1962 and 1963) and the United States National Center for Health Statistics for Washington, D.C. (1964 and 1965). Both these latter institutions also provide foreign expertise and advice.
2. Comparisons of totals may yield deceptively similar results if it so happens that events add up to a similar number, but individual items which went to make up the totals may not be the same.

caught by one operation only. From the three categories an estimate is made of the fourth category: events missed by both operations. The experiment is based on a set of involved procedures which require hundreds of pages of description in several manuals and their intricacy and the endeavour to provide for every contingency must not be underestimated, particularly in the case of the more obvious situations (Muhsam, 1964, p. 43).

First application of the Chandra-Deming formula

It is not intended to spread the PGE over the whole of Pakistan. In circumstances where there are advantages to a certificate of non-registration, rather than the registration (Krótki, 1965*a*), there is no reason why the whole country should be covered by a comprehensive system and anyhow, whatever the intention, it will not be so covered in the foreseeable future. In such circumstances it is not helpful to view the sample as a temporary measure (Chevry, 1965, p. 4). It should remain a permanent feature of Pakistani demography.

Apart from its being not a stop-gap arrangement but a permanent solution to Pakistani needs, it is also the first application of the formula suggested for the estimation of the 'fourth category' of events, i.e., events omitted by both parts of the experiment (Chandra and Deming, 1949). There have been earlier attempts at comparing documents from two different operations, e.g., the Mysore study (United Nations, 1961, p. 22, 226 and others), but they did not use fully the theoretical apparatus suggested by Chandra and Deming. The novelty of this approach lies in the departure from attempting a better and better (decreasing returns?) sample on orthodox lines (ISI, 1963). Currently, a related activity has been started in Thailand (Thailand, 1964) and, it is understood, in Turkey and Egypt. A continuing sample survey to determine more accurately births and deaths has been reported from Rhodesia[1] but it is not clear whether it is in line with modern developments or along more traditional lines.

Unorthodox applications

The important analytical uses to which age distribution can be put have been described. Results can be obtained even with poor data because with the high fertility typical of underdeveloped countries the base of the age pyramid is wide. There are other uses to which age distributions can be put, less important but interesting, because they show the age distribution as a mirror of the demographic past.

Temporariness of urban migration

The age distributions of East and West Pakistan were grouped into four homogeneous distributions. It has been shown that there was a reverse

1. *Bulletin de l'Institut International de Statistique*, tome 32, p. 113.

correlation between the rate of growth as reported by censuses and the extent of migration as indicated by irregularities in age distributions (Krótki, 1963*a*). In other words, the more immigrants a town received (swellings in the middle on the male side of the age pyramid) the slower it grew. The hypothesis has arisen that the immigrants are temporary and return having achieved some limited purpose of the migration, the very temporariness sharpening up the male swelling by not encumbering them with children, old people and womenfolk. Not unreasonable rationalizations of an anthropological nature can be suggested to fit this hypothesis. If it is true, much of such urbanization is spurious.

Age at male puberty, female puberty and menopause

During the First Population Census of Sudan 1955-56 no questions were asked about ages (except for infants). Instead, meaningful answers—it was found—were obtained about the three stages of the human cycle given in the title of this subsection. The census-takers concerned were quite prepared to think in terms of these three points, as if they were points on a topological scale (imaginary stretchable age axis). Fortunately, it proved possible to assign to these points age values through a study of age distributions (Krótki, 1965*b*). The fortunate part was due to the fact that the youngest ages were so numerous that the base of the age pyramid proved very wide. Once the horizontal axis was wide and the vertical axis remained the same as in other populations (some old people must have survived even in the Sudanese population), the large group between infants and the aged could be spread like a sail between the boom of the y axis and the mast of x axis in a limited number of ways only all of them producing identical or similar ages at male puberty, female puberty and menopause.

The problems of the denominator

The classical problem arises out of the fact that vital events occur throughout the year and it is difficult to determine to which population they refer. The correct answer that it is the total number of man-years lived by the population experiencing the vital events, is operationally not very helpful, though important to surveys based on small samples. There is an example of a very ingenious attempt to calculate the correct 'exposure time' in Brazil (United Nations, 1964*a*, paras. 21 and 22).

The real problem of the denominator lies in the fact that surveyors interested in the numerator (number of vital events) somehow do not exert themselves to obtain exact population totals. The spiritual fathers of the PGE experiment spare the denominator no single thought (Chandra and Deming, 1949). The immediate godfather does not mention it (Coale, 1963*b*). The putative fathers pay it some lip service (Ahmed and Krótki, 1963), but for a long time did nothing about it (Ahmed and Krótki, 1964). There is probably a certain degree of incompatability between the two

interests, perhaps only a hangover, because historically the two sides were furnished by different agencies. Certainly considerable ingenuity is required to combine in one inquiry the total population *and* the events of exactly the same population (defined in its *de facto* or *de jure* man-years).

BIBLIOGRAPHY

AHMED, Nazir; KRÓTKI, Karol J. 1963. Simultaneous estimations of population growth—the Pakistan experiment. *Pakistan Development Review*, 3(1): 37-65. Spring 1963.

——; ——. 1964. Second report on the Population Growth Estimation experiment. *Indian Population Bulletin* (in print). A summary of same article appeared in *Abstracts of papers contributed by individual authors to the Asian Population Conference: Pakistan*, p. 2. New Delhi, Office of the Registrar-General of India, 1963.

BLACKER, J. G. C.; MARTIN, C. J. 1963. Old and new methods of compiling vital statistics in East Africa. *International Population Conference, New York, 1961* (cited below), vol. II, p. 355-62.

BOURGEOIS-PICHAT, Jean. 1953. *Un essai d'évaluation de la précision des statistiques démographiques d'un pays sous-développé: La Thaïlande.* Nations Unies/SOA-TOA. (Documents de travail: LA/9.AFE/9.)

BRASS, W. 1963. The construction of life tables from child ratios. *International Population Conference, New York, 1961* (cited below), vol. I, p. 294-301.

CARRIER, N. H.; FARRAG, A. M. 1959. The reduction of errors in census populations for statistically underdeveloped countries. *Population Studies*, 12(3): 240-85.

CAVANAUGH, J. A. 1963. Sample vital registration experiment. *International Population Conference, New York, 1961* (cited below), tome II, p. 363-71.

CHANDRA, C.; DEMING, W. Edward. 1949. On a method for estimating birth and death rates and the extent of registration. *Journal of the American Statistical Association*, 44: 101-15.

CHANDRASEKARAN, C. 1964. Fertility indices from limited data. *International Population Conference, Ottawa, 1963* (cited below), p. 91-106.

CHEVRY, G. R. 1965. Les techniques de sondage dans l'élaboration des statistiques démographiques. *Nations Unies, Congrès mondial de la population, Belgrade.* Mimeographed document for distribution to participants only.

CLAIRIN, Rémy. 1964. Les données susceptibles d'être utilisées pour une évaluation du mouvement de la population en Afrique au sud du Sahara. *International Population Conference, Ottawa, 1963* (cited below), p. 107-20.

COALE, Ansley J. 1955. The population of the United States in 1950 classified by age, sex and colour—a review of census figures. *Journal of the American Statistical Association*, 50: 16-54.

——. 1956. The effects of changes in mortality and fertility on age composition. *Milbank Memorial Fund Quarterly*, 34(1): 80-114, January 1956.

——. 1963*a*. Estimates of various demographic measures through the quasi-stable age distribution. *Emerging techniques in population research*, p. 175-93. New York, Milbank Memorial Fund.

——. 1963*b*. The design of an experimental procedure for obtaining accurate vital statistics. *International Population Conference, New York, 1961* (cited below), vol. II, p. 372-5.

——; DEMENY, Paul. 1964. *Regional model life tables and stable populations.* Princeton University, Office of Population Research. Mimeographed introduction (preliminary version, not for quotation), 80 p. Photostated tables, p. 871.

——; HOOVER, Edgar M. 1958. *Population growth and economic development in low-income countries. A case study of India's prospects.* Princeton, N.J., the University Press.

DEMENY, Paul. 1965. Estimation of vital rates for populations in the process of destabilization. Paper presented at the June 1964 meetings of the Population Association of America, to be published in *Demography*.

EL-BADRY, M. A.; CHANDRASEKARAN, C. 1963. Some methods for obtaining vital statistics in India. *International Population Conference, New York, 1961* (cited below), vol. II, p. 377-86.

FELLEGI, I. P. 1964. Response variance and its estimation. *Journal of the American Statistical Association*, 59(308): 1016-41, December 1964.

INDIAN STATISTICAL INSTITUTE (ISI). 1963. The use of the National Sample Survey in the estimation of current birth and death rates in India. *International Population Conference, New York, 1961* (cited below), vol. II, p. 395-402.

International Population Conference, New York, 1961. London, International Union for the Scientific Study of Population, 1963.

International Population Conference, Ottawa, 1963. Liège, International Union for the Scientific Study of Population, 1964.

KRÓTKI, Karol J. 1961*a*. A correction to infant mortality. *Sudan Notes and Records*, 42: 53-84.

——. 1963*a*. Temporariness of urban migration estimated from age distributions in large and small towns of East and West Pakistan. *Proceedings of the Pakistan Statistical Association*, 77: 115-26; 4 graphs.

——. 1963*b*. Population size, growth and age distribution—fourth release from the 1961 Census of Pakistan. *Pakistan Development Review*, 3(2): 179-305, summer 1963.

——. 1964. Seasonality of vital events in East and West Pakistan. *Indian Population Bulletin* (in press). A summary of this article appeared in *Abstracts of papers contributed by individual authors to the Asian Population Conference: Pakistan*, p. 4. New Delhi, Office of the Registrar-General of India, 1963.

——. 1965*a*. The problem of estimating vital rates in Pakistan. *United Nations World Population Conference, Belgrade*. Mimeographed document for distribution to participants only.

——. 1965*b*. Finding age at reported puberties and menopause through a graphical method. *Population Studies, London* (in press).

——; HASHMI, Sultan S. 1962. Report on a census enumeration. *Pakistan Development Review*, 2(3): 378-405, autumn 1963.

LINDER, Forrest E. 1965. The increased scope of demographic investigations through the use of sampling surveys. *United Nations World Population Conference, Belgrade*. Mimeographed document for distribution to participants only.

LORIMER, Frank. 1946. *Population of the Soviet Union*. Geneva, League of Nations.

LOTKA, Alfred J. 1939. *Théorie analytique des associations biologiques*. Deuxième partie : Analyse démographique avec application particulière à l'espèce humaine. Paris, Hermann.

MUHSAM, H. V. 1964. Moderator's introductory statement: vital statistics from limited data. *International Population Conference, Ottawa, 1963* (cited above), p. 25-46.

POPULATION COUNCIL. 1963*a*. *Studies in family planning*. No. 1. April 1964. New York, The Population Council.

——. 1963*b*. *Studies in family planning*. No. 2. December 1963. New York, The Population Council.

ROBERTS, G. W. 1963. Improving vital registration in the West Indies. *International Population Conference, New York, 1961* (cited above), vol. II, p. 420-6.

SAXENA, G. B. 1965. Estimates of birth rate and expectation of life in India on the basis of quasi-stability. *United Nations World Population Conference, Belgrade*. Mimeographed document for distribution to participants only.

TAEUBER, Conrad. 1965. New concepts in census methodology. *United Nations World Population Conference, Belgrade*. Mimeographed document for distribution to participants only.

THAILAND. NATIONAL STATISTICAL OFFICE. 1964a. *Survey of population changes: study outline.* July 1964. Mimeographed.

UNITED NATIONS. DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS. 1955. *Age and sex patterns of mortality. Model life tables for under-developed countries.* New York. (Population studies, no. 22.)

——. 1961. *The Mysore Population Study.* New York. (Population studies, no. 34.)

——. 1964a. *Guanabara demographic pilot survey.* New York. (Population studies, no. 35.)

——. 1964b. *Provisional report on world population prospects, as assessed in 1963.* New York.

VALAORAS, V. G. 1965. Testing deficiencies and analytical adjustments of vital statistics. *United Nations World Population Conference, Belgrade.* Mimeographed document for distribution to participants only.

VANGREVELINGHE, G. 1965. Les enquêtes par sondage dans le contrôle des recensements démographiques. *United Nations World Population Conference, Belgrade.* Mimeographed document for distribution to participants only.

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